

# **Relation of Water Quality to Land Use in the Drainage Basins of Six Tributaries to the Lower Delaware River, New Jersey, 2002-07**

**Ron Baker and Rachel Esralew, USGS, New Jersey Water Science Center, Trenton, NJ., in cooperation with the New Jersey Department of Environmental Protection**



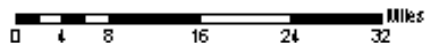
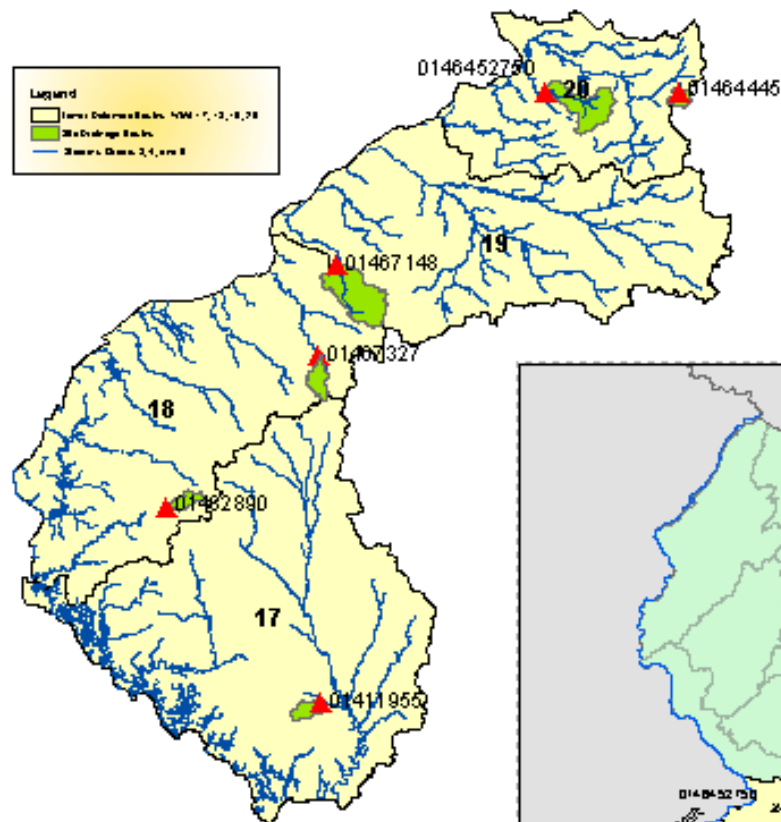
# Study Objectives

- To determine nutrient concentrations and loads for streams in the Lower Delaware watershed
- To assess the relations between land use and nutrient concentrations and loads
  - Annually and seasonally
  - During runoff and baseflow conditions

# Methods

- Six streams were selected in varying land-use basins:
  - 2 urban, 2 undeveloped, 2 agricultural
- Samples were collected and streamflow was measured
  - 8 runoff events, 8 baseflow events
  - 8 during the growing season, 8 during the nongrowing season
- Concentrations and loads of nutrients were determined
  - Nitrogen and phosphorus species
  - Mean and variability of concentrations and loads
- Nonparametric statistical relations (ANOVA and multiple comparisons of ranked data) between nutrient values and explanatory variables (land use, season, hydrologic conditions) were determined

# Lower Delaware Non-Point Source Study Site Map



## Legend

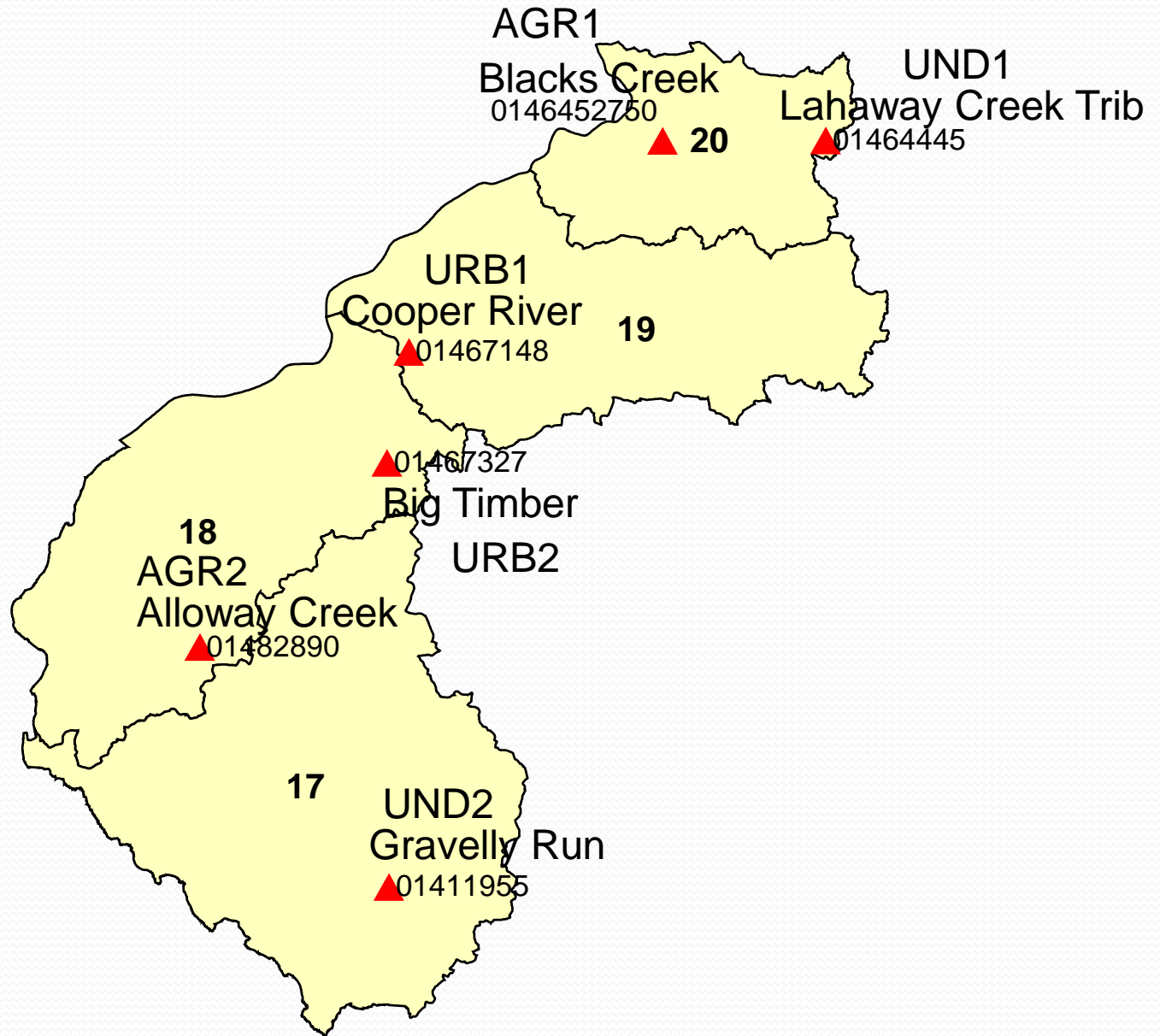
### Lower Delaware Sites

- ▲ 01411955 Gravelly Run near Laurel Lake, NJ
- ▲ 01464445 Lahavey Creek tributary near Rosedale, NJ
- ▲ 0146452750 Black Creek near Chatsfield, NJ
- ▲ 01467148 Coopers River at Haddonfield, NJ
- ▲ 01467327 South Branch Big Timber Creek at Granton, NJ
- ▲ 01462890 Alloway Creek near Watsons Corner, NJ

Map by Rachel Caslow, 04-0004  
US Geological Survey, Water Resources Division

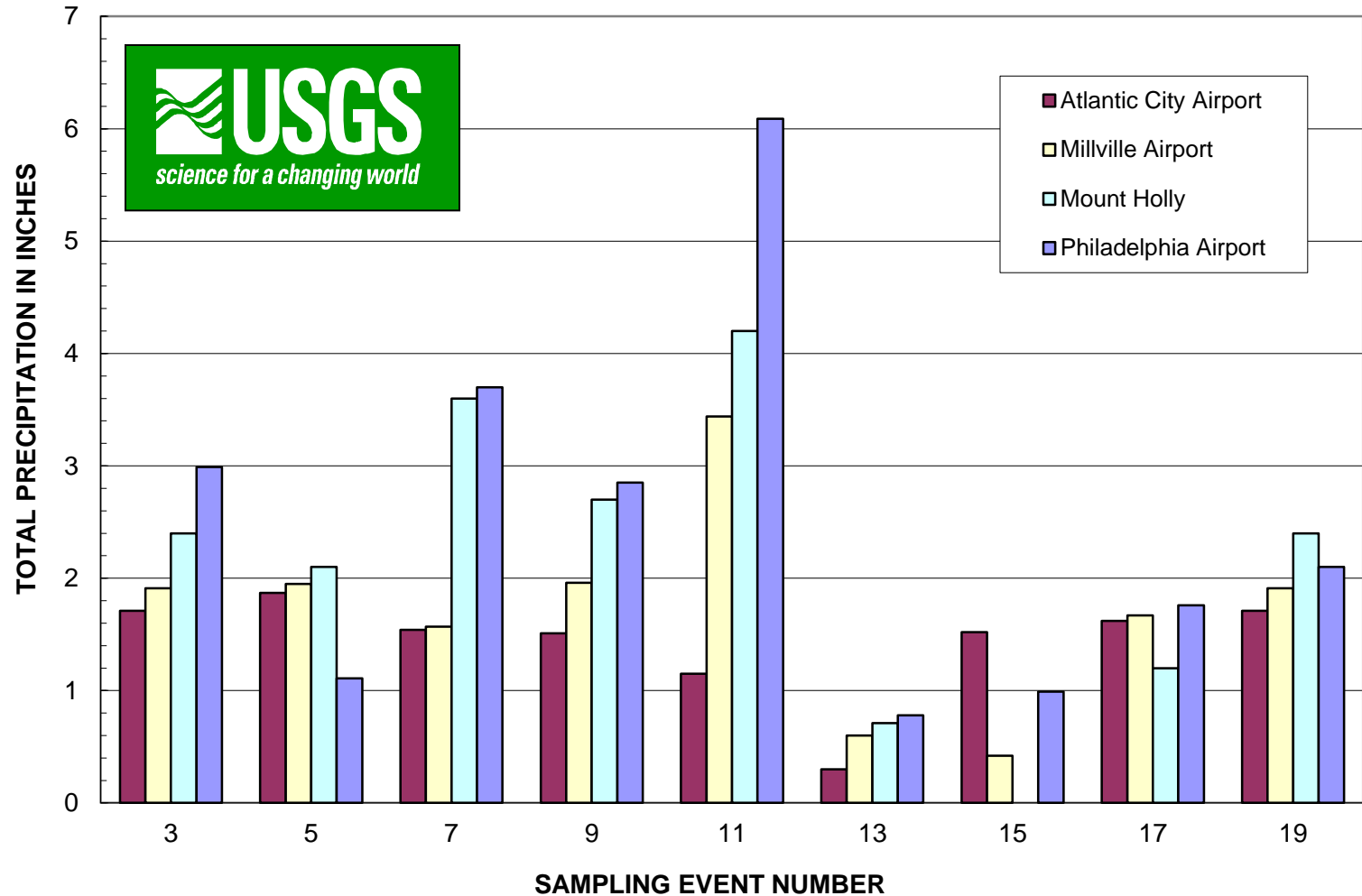


# Site Locations

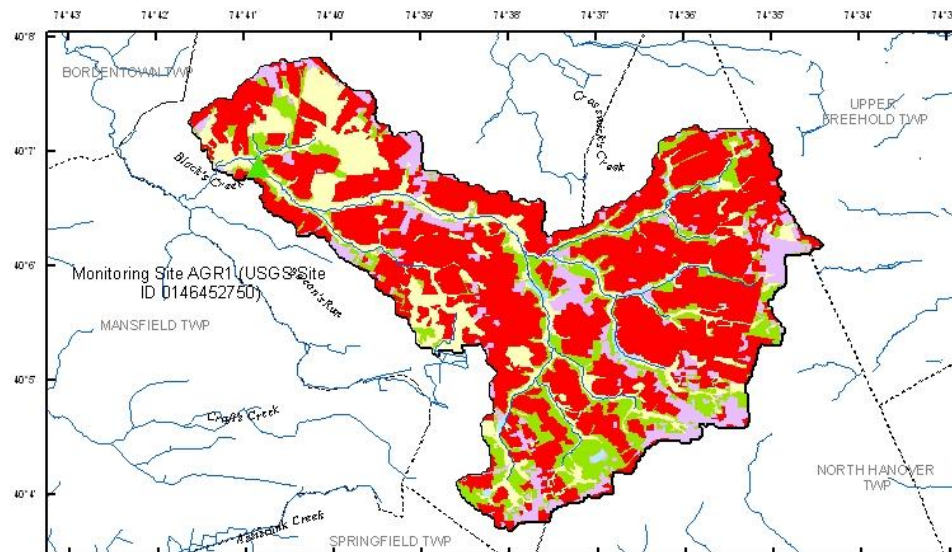


# Precipitation during storm events varies significantly among sites:

Total Precipitation During Storm-Sampling Events at Three Weather Stations







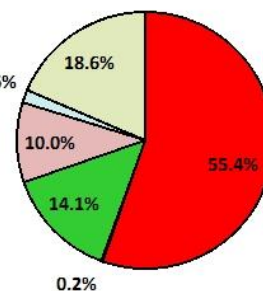
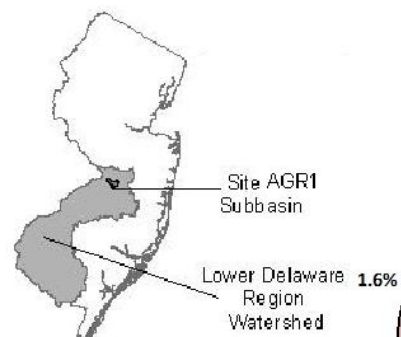
#### EXPLANATION

- ▲ Monitoring Site
- Township Boundary

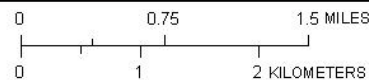
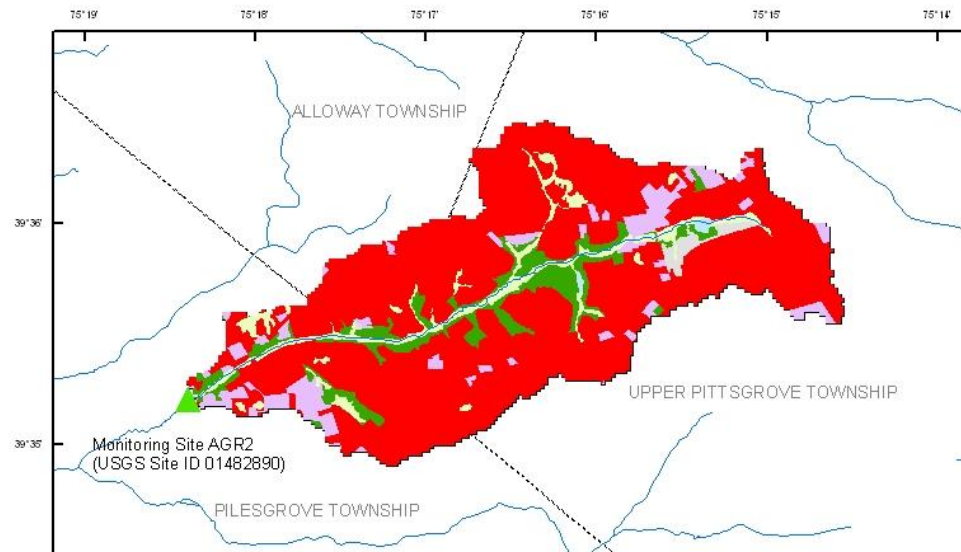
LANDUSE - From N.J. Department of Environmental Protection, digital data file, 2002

- Agriculture
- Barren Land
- Forest
- Urban
- Water
- Wetlands

Area: 13.2 square miles



Blacks Creek near Chesterfield (AGR1)



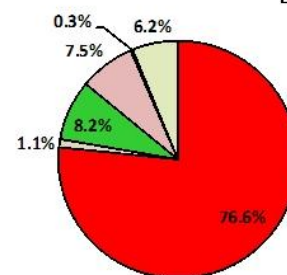
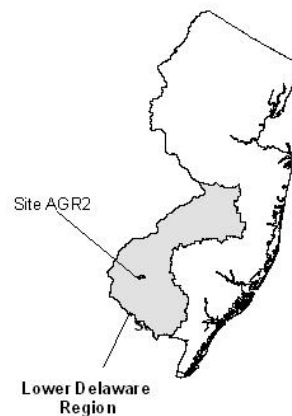
#### EXPLANATION

- ▲ Monitoring Site
- Township Boundary

LANDUSE - From N.J. Department of  
Environmental Protection, digital data file,  
2002

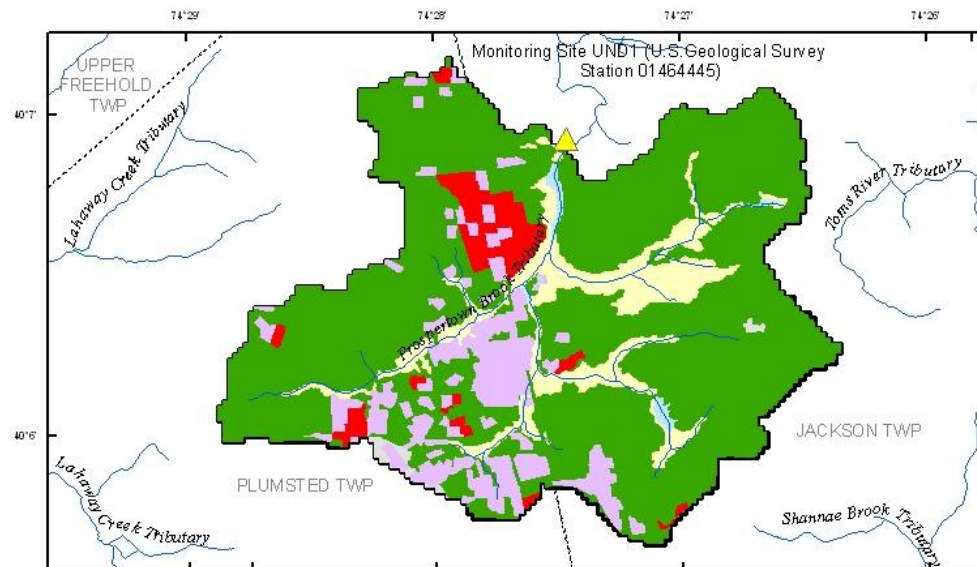
- Agriculture
- Barren Land
- Forest
- Urban
- Water
- Wetlands

Area: 3.0 square miles



Alloway creek near Watson Corner (AGR2)





#### EXPLANATION

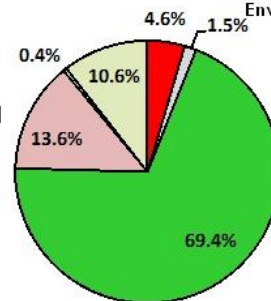
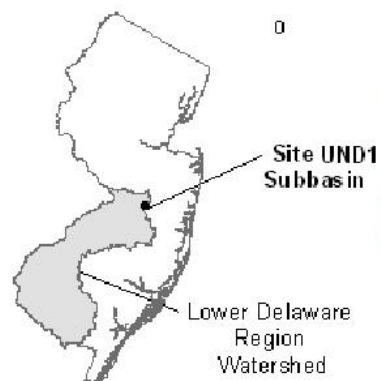
▲ Monitoring site

----- Township boundary

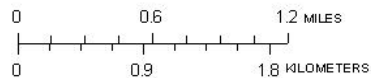
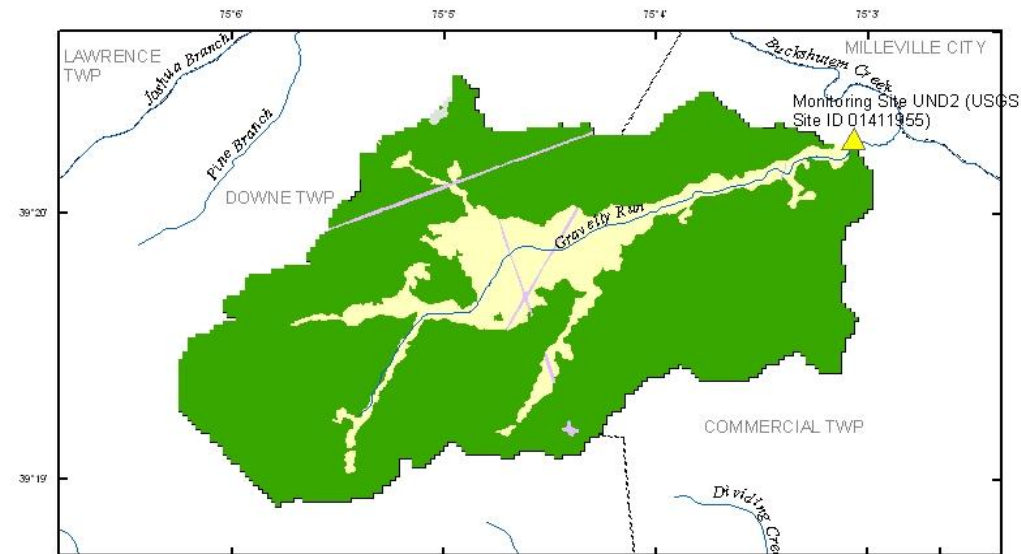
LANDUSE - From N.J. Department of Environmental Protection, digital data file, 2002

Agriculture  
 Barren Land  
 Forest  
 Urban  
 Water  
 Wetlands

Drainage area: 2.3 square miles



Lahaway Creek Trib. Near Prospertown (UND1)



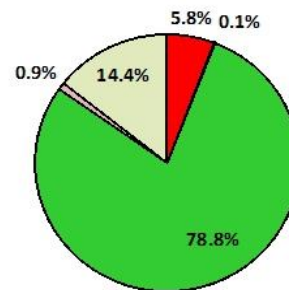
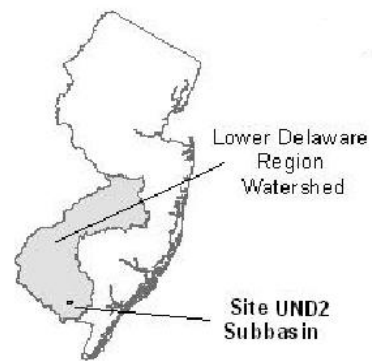
#### EXPLANATION

- ▲ Monitoring Site
- Township Boundary

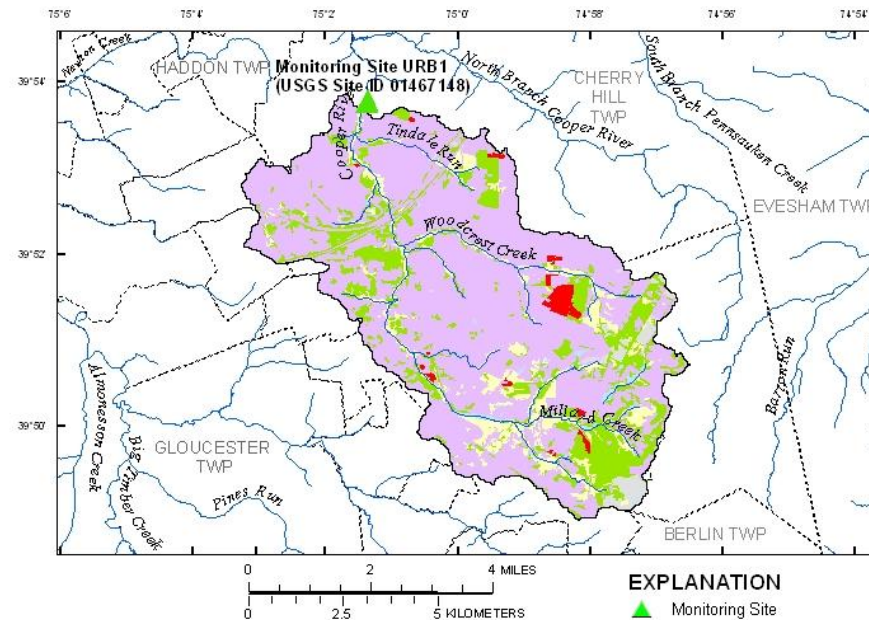
LANDUSE - From N.J. Department of Environmental Protection, digital data file, 2002

- Agriculture
- Barren Land
- Forest
- Urban
- Water
- Wetlands

Area: 3.3 square miles



Gravelly Run at Laurel Lake (UND2)



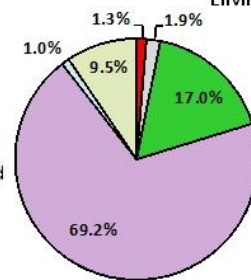
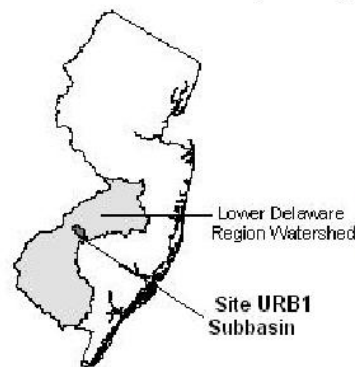
#### EXPLANATION

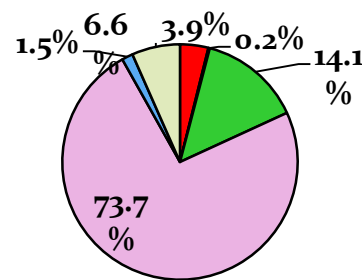
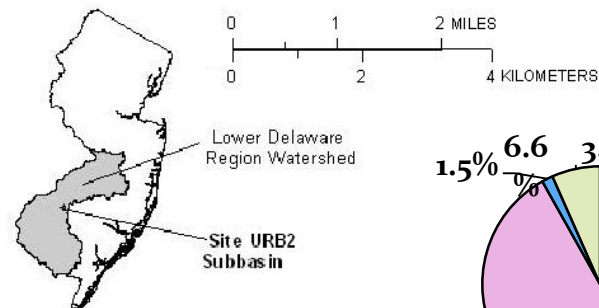
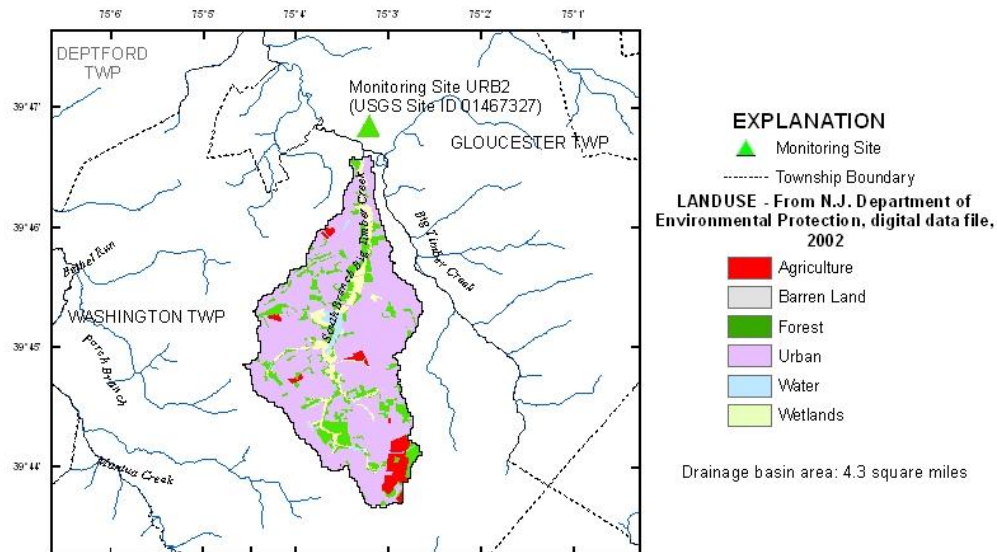
- ▲ Monitoring Site
- Township Boundary

LANDUSE - From N.J. Department of Environmental Protection, digital data file, 2002

- Agriculture
- Barren Land
- Forest
- Urban
- Water
- Wetlands

Area: 17.8 square miles





**S. Branch Big Timber Creek Trib. (URB2)**

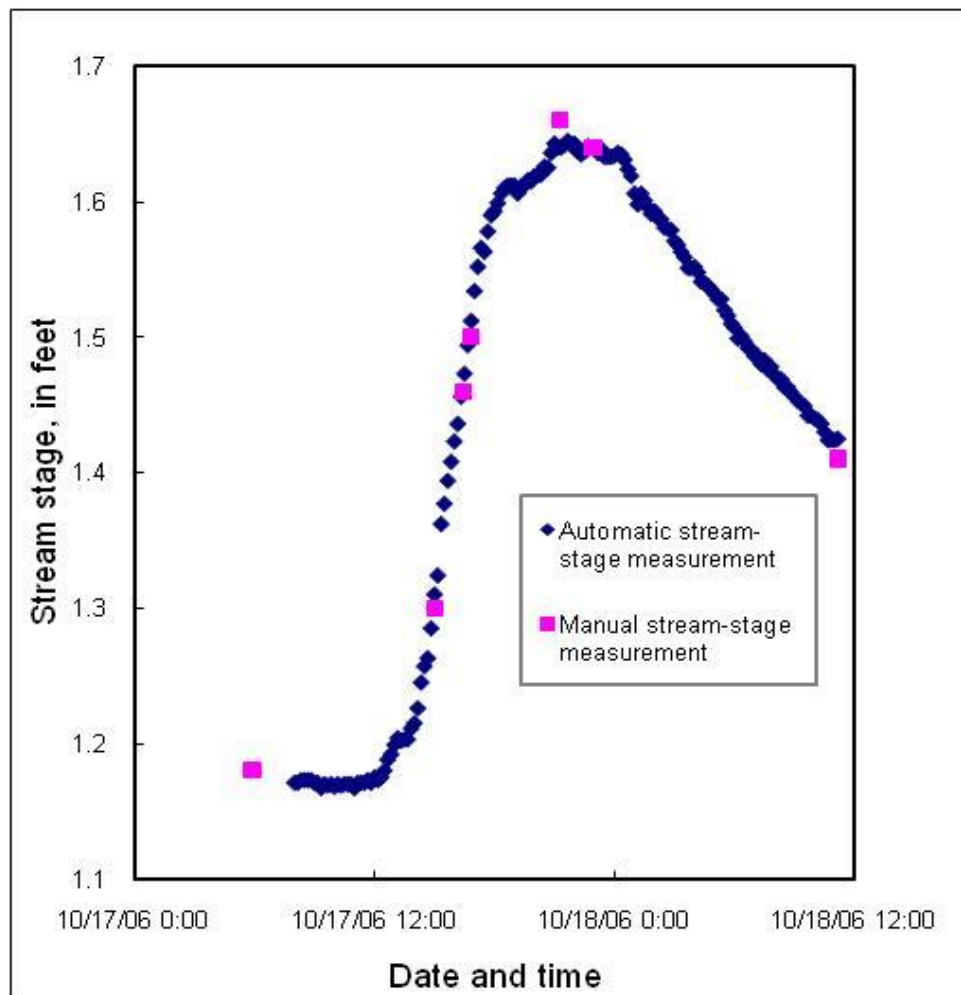


Figure 10. Example of a stream-stage hydrograph which includes automatic and manual stream-stage measurements for URB2, South Branch Big Timber Creek Tributary at Grenloch, New Jersey, October 17-18, 2006.



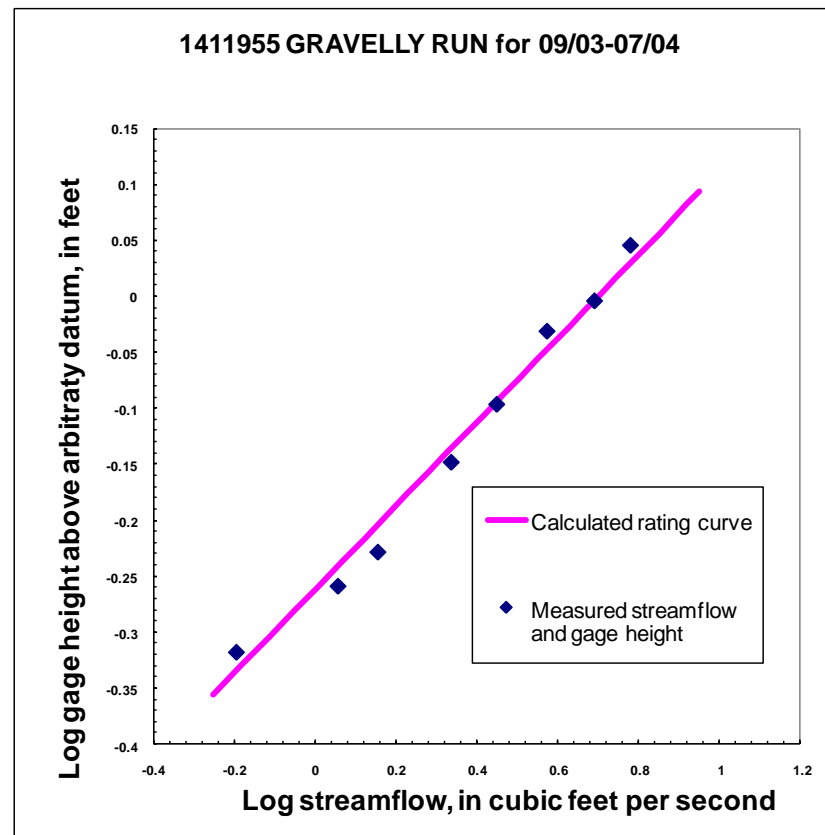
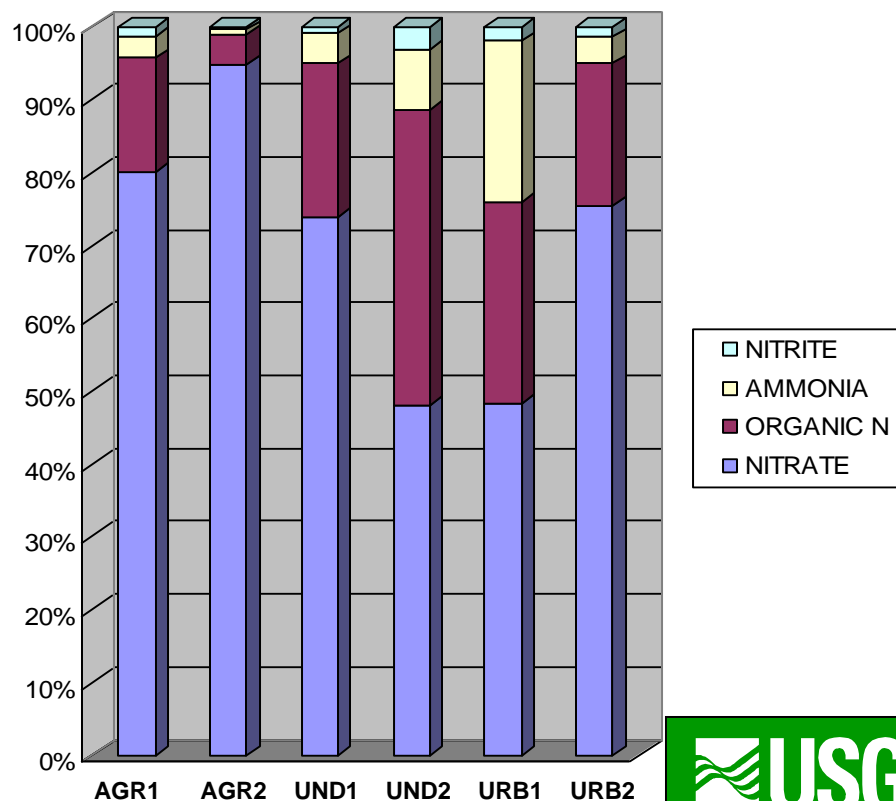
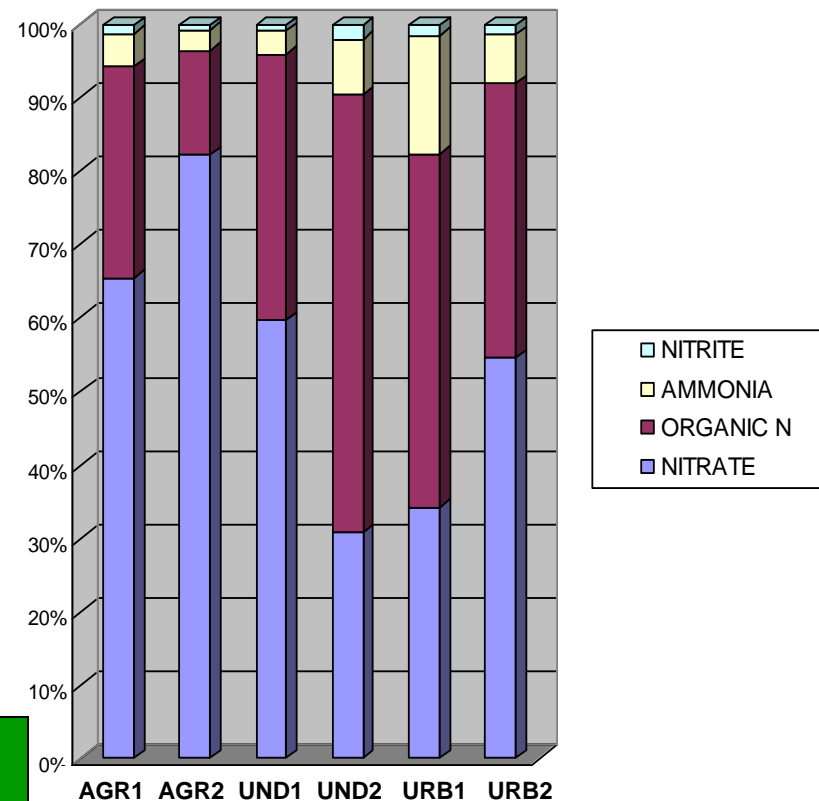


Figure 9. Example of a rating curve used for determining streamflow (discharge) values from measured stream stage for site UND2, Gravelly Run at Laurel Lake, New Jersey

## Relative median concentrations of nitrogen species during baseflow



## Relative median concentrations of nitrogen species during storm flow



### ---Mean % of total nitrogen concentration---

Hydrologic conditions	Nitrite	Nitrate	Organic N	Ammonia
Base flow	1	85	11	3
Stormflow	1	61	32	6

# Event Mean Concentrations

Site	----- TN Conc. -----			----- TP Conc. -----		
	Annual	Growing	Nongrowing	Annual	Growing	Nongrowing
AGR1	2.00	2.20	1.49	0.40	0.56	0.20
AGR2	1.81	2.06	1.45	0.63	1.00	0.11
UND1	0.86	0.9	0.75	0.06	0.07	0.03
UND2	0.36	0.40	0.32	0.03	0.02	0.03
URB1	0.98	1.14	0.75	0.55	0.82	0.16
URB2	0.88	0.96	0.72	0.08	0.09	0.05

## Observations:

- Higher EMCs in growing season (TN and TP)
- Higher EMCs at AG sites (TN)
- High EMCs at URB1 (TP)
- Lowest EMCs at least developed site (UND2: TN and TP)

# Are these streams nitrogen or phosphorus limited?

Base-flow conditions		
Stream	N:P ratio	Limiting nutrient
AGR1	117	Phosphorus
AGR2	67.9	Phosphorus
UND1	22.5	Phosphorus
UND2	7.02	Nitrogen
URB1	5.42	Nitrogen
URB2	39.2	Phosphorus

---

Stormflow conditions		
Stream	N:P ratio	Limiting nutrient
AGR1	15.5	Either
AGR2	6.73	Nitrogen
UND1	18	Either
UND2	12.6	Either
URB1	1.91	Nitrogen
URB2	14.1	Either

## **Statistical Analysis of Data: Comparisons among Sites and between Growing and Nongrowing Seasons**

Parameters tested:

- Concentrations of nutrient species
- Yields of nutrient species

Statistical analyses:

- Nested ANOVA of ranks
- Nested Tukey Test of ranks

Ho1: No difference between growing and nongrowing seasons

Ha1: Significant difference between growing and nongrowing seasons

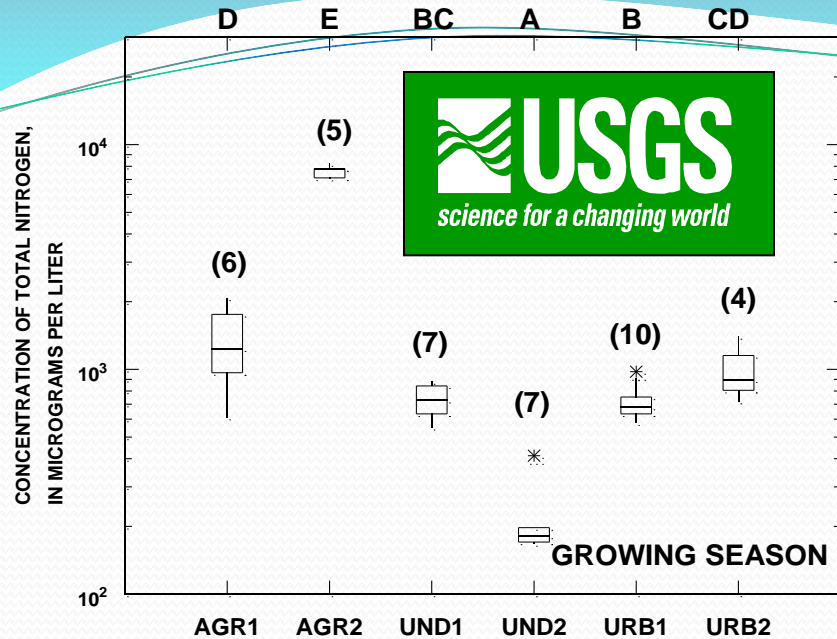
Ho2: No difference among the six streams

Ha2: Significant differences among the six streams

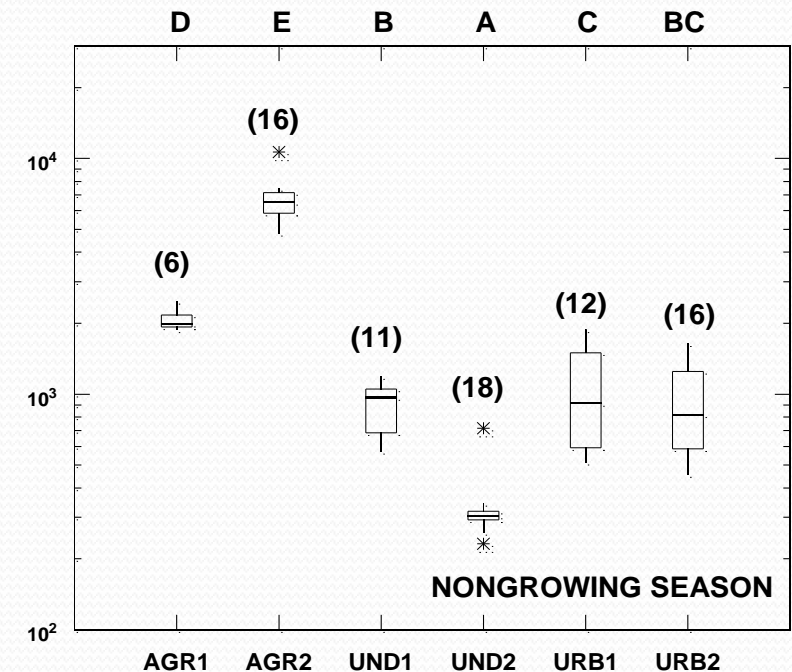
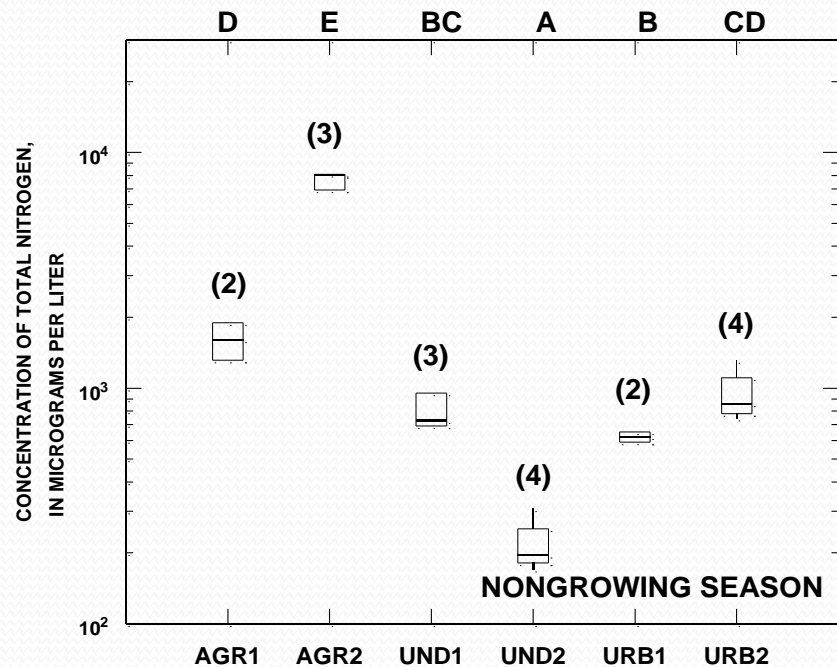
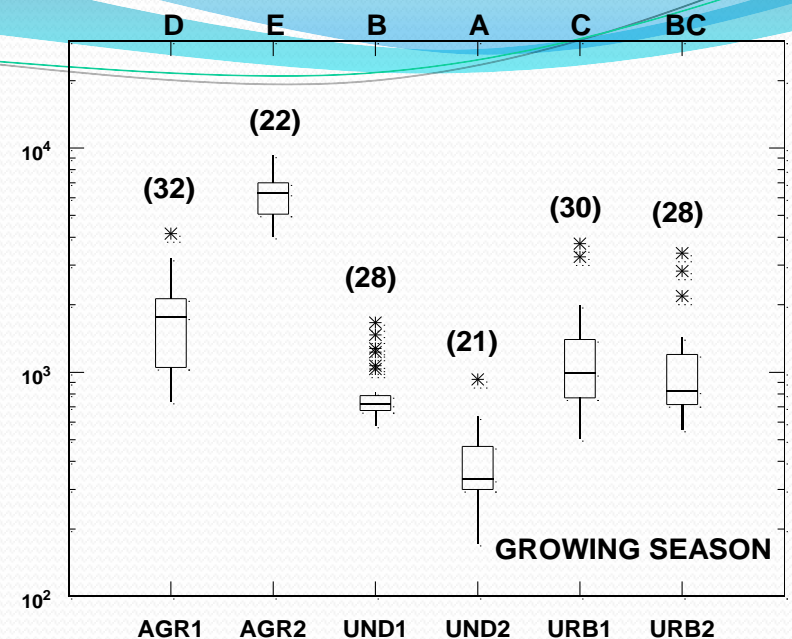
Level of significance for all tests: 0.05



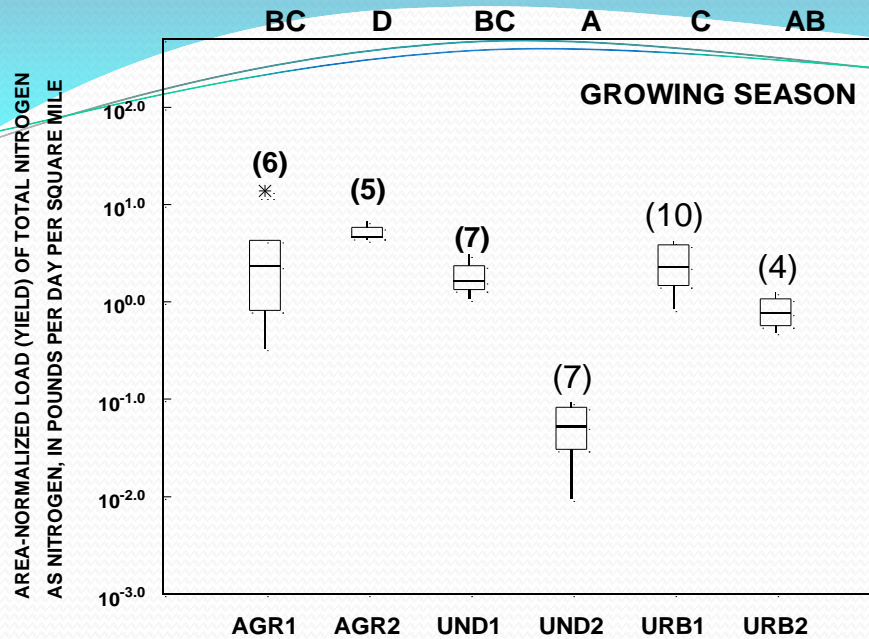
## BASE FLOW



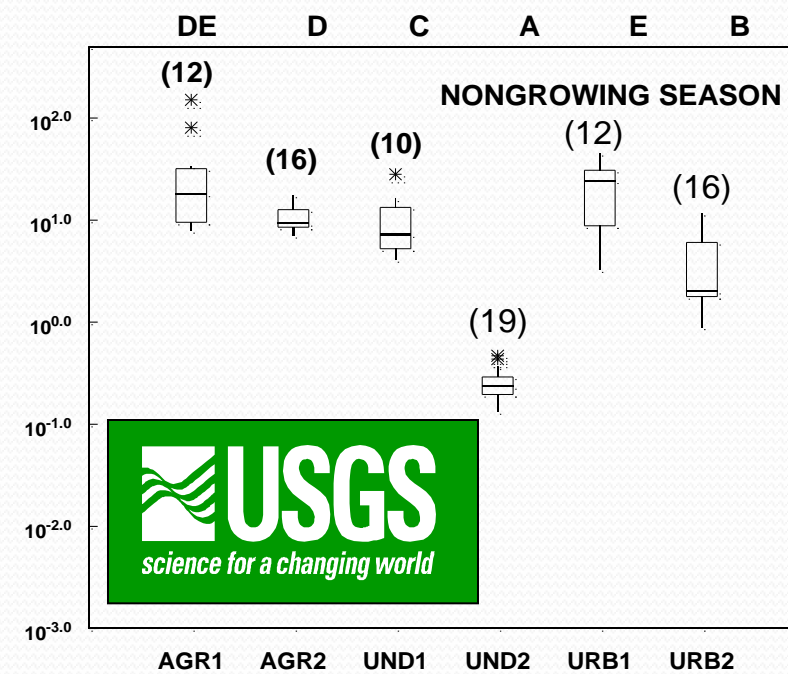
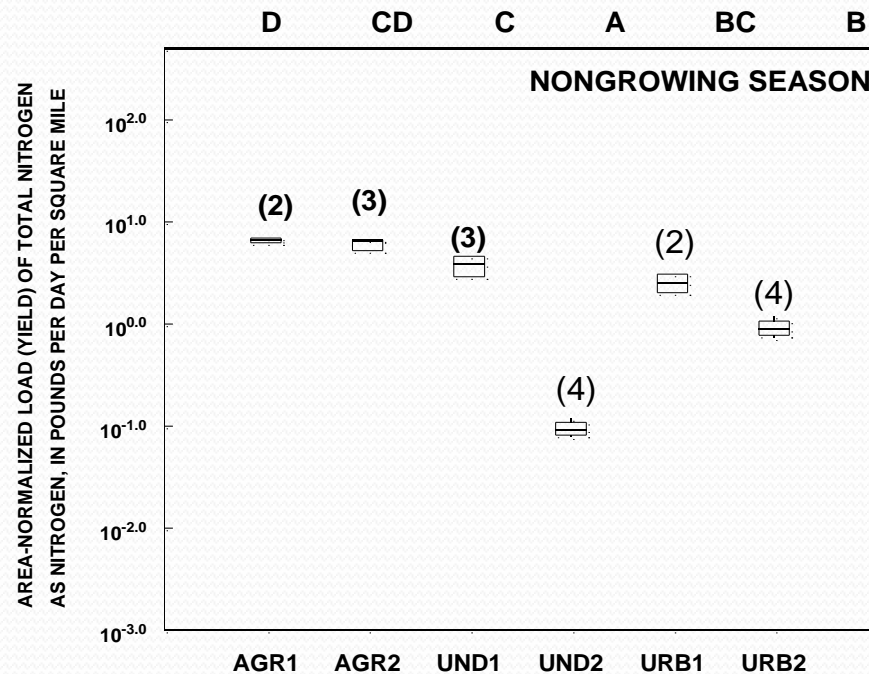
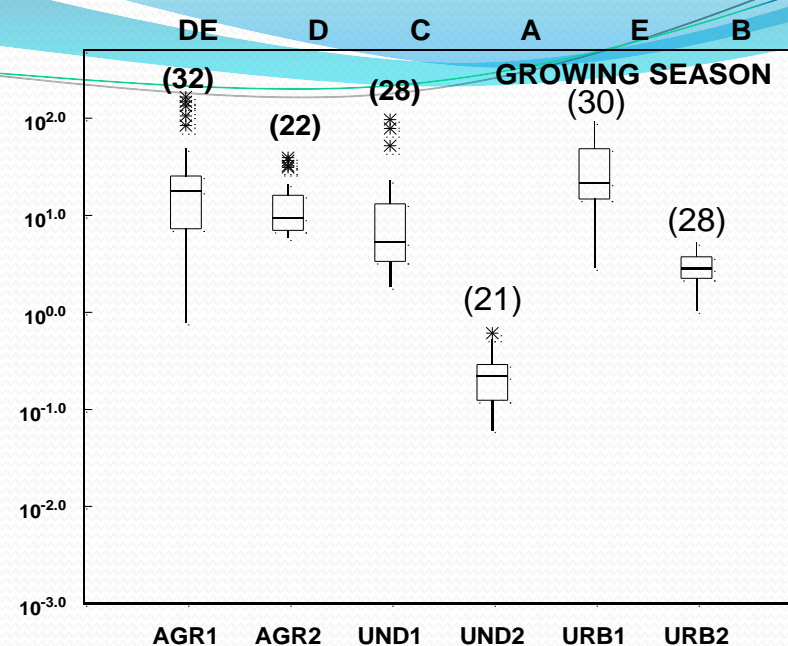
## STORMFLOW



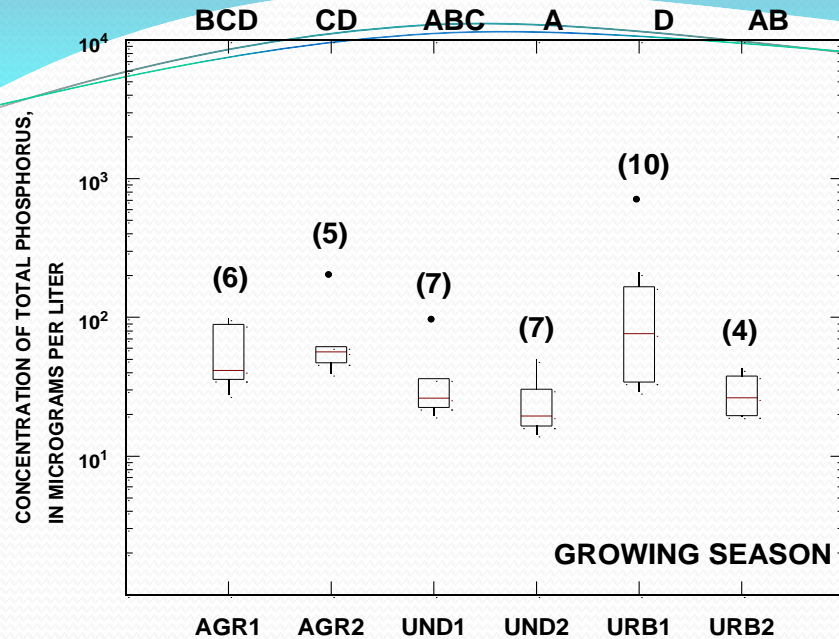
## BASE FLOW



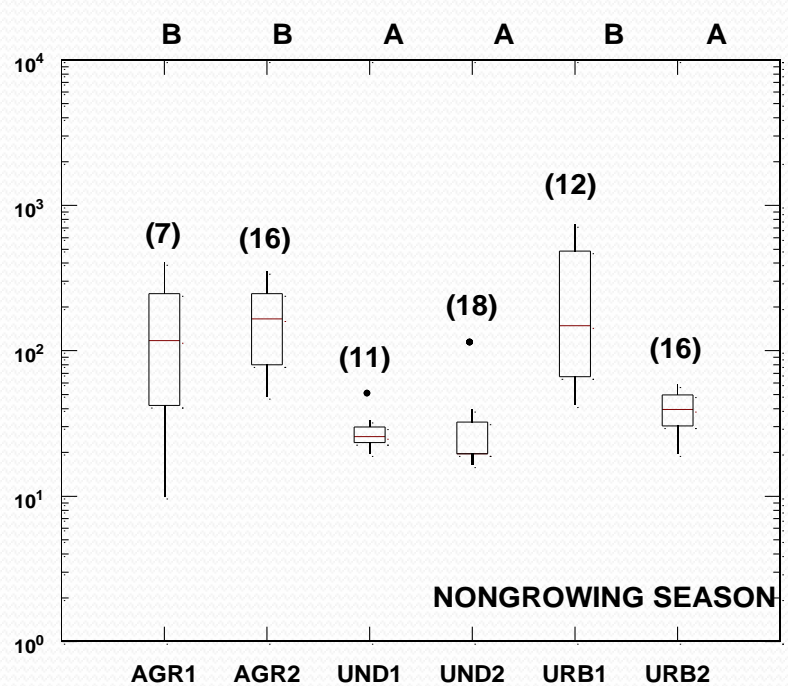
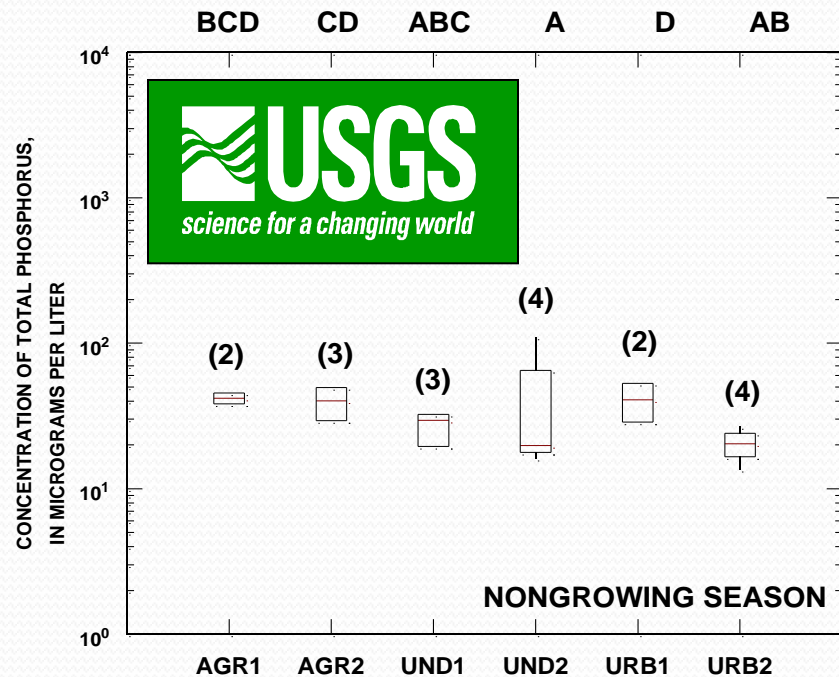
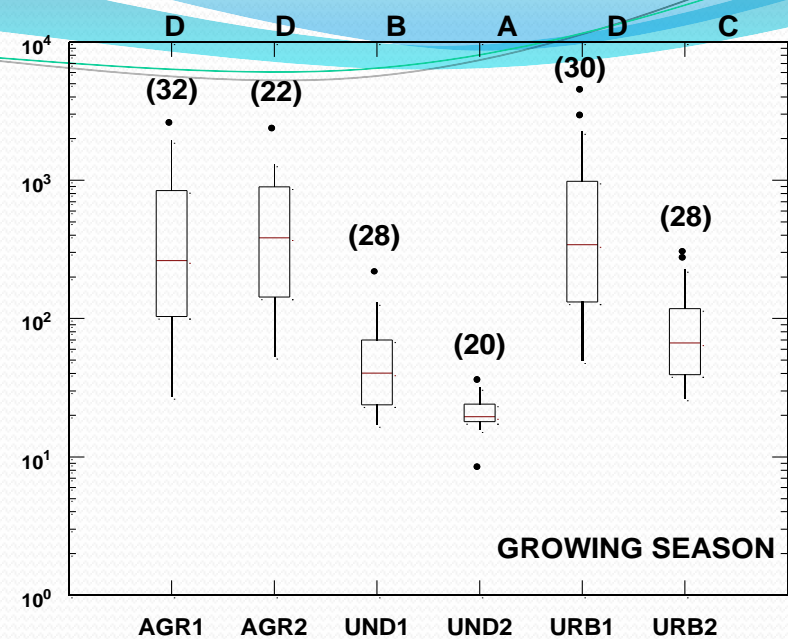
## STORMFLOW



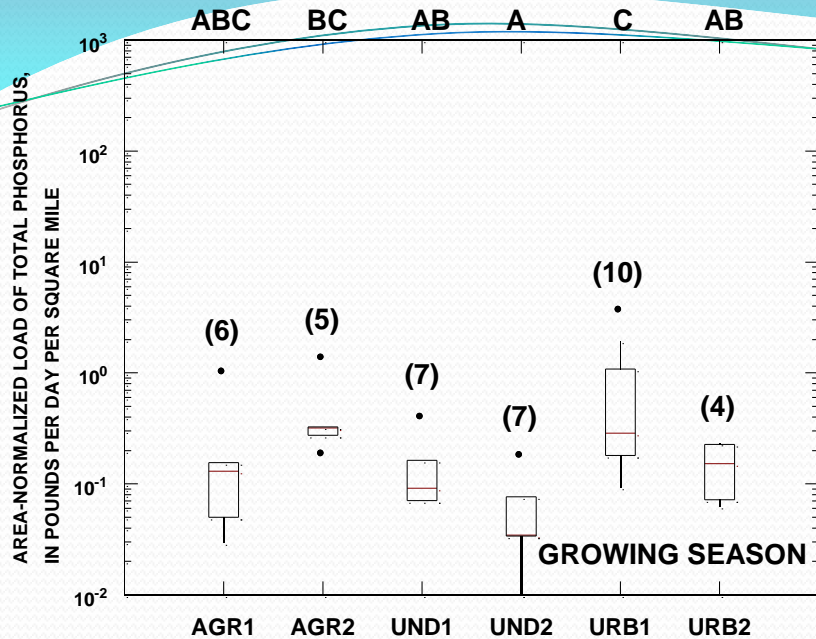
## BASE FLOW



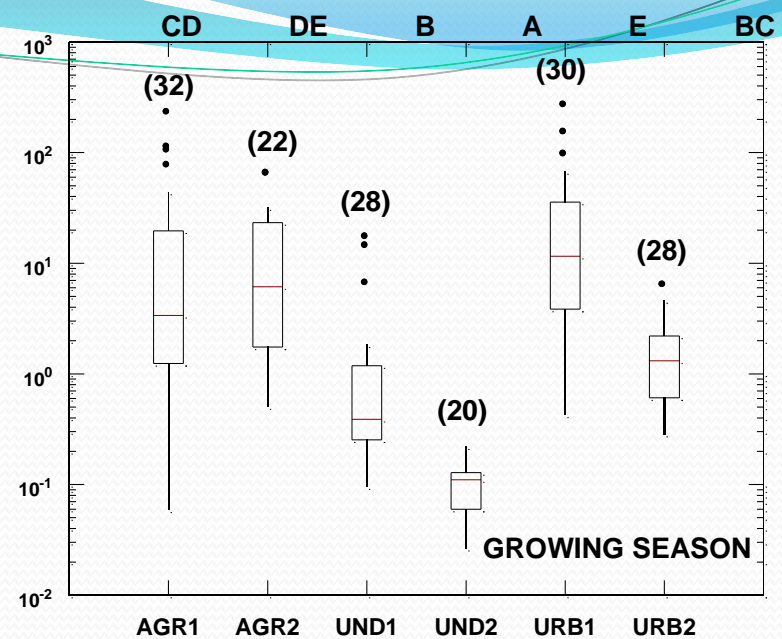
## STORMFLOW



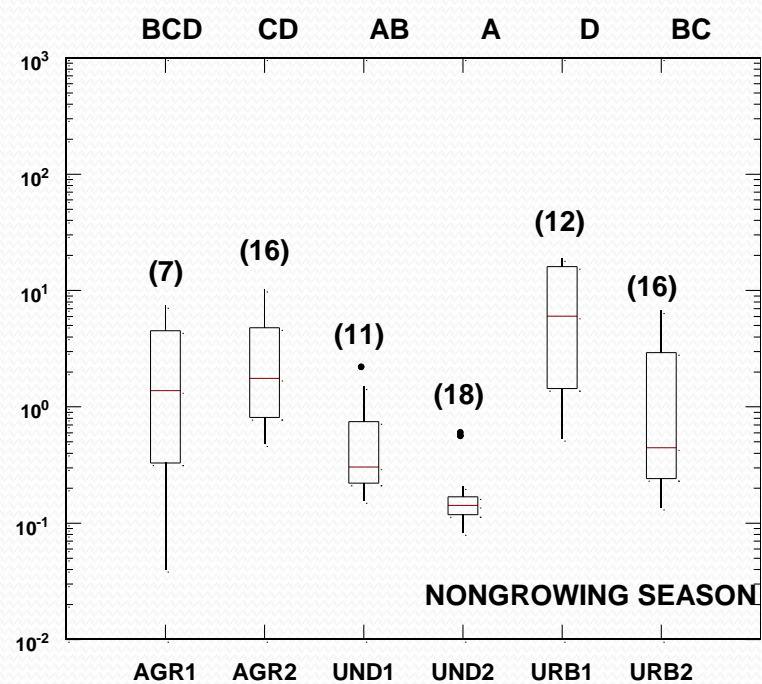
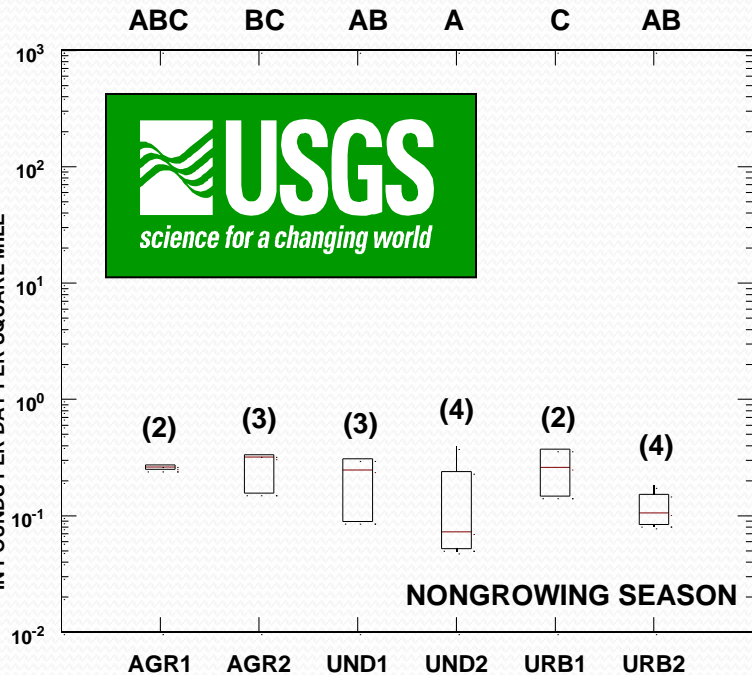
## BASE FLOW



## STORMFLOW



AREA-NORMALIZED LOAD OF TOTAL PHOSPHORUS,  
IN POUNDS PER DAY PER SQUARE MILE



# Observations

## **Total nitrogen:**

Conc. of filtered samples =  $0.95 \times$  conc. of unfiltered samples

Conc. and loads highest in agricultural sites, lowest in undeveloped sites

Highest in AGR2 (Alloway), which has highest %AG + cattle

Lowest in UND2 (Gravelly), which has the lowest % development

## **Nitrate plus nitrite:**

Nitrite always insignificant

Nitrate conc. and yields highest in AGR2, lowest in UND2

## **Ammonia:**

Only 3-6% of total N for all sites

## **Organic nitrogen:**

10-35% of total N.

Similar concentrations among developed and undeveloped basins

Natural and man-made sources



# Observations

## **Total phosphorus:**

Much higher in stormflow samples than in base-flow samples  
(sorption of P to sediment and particulates)

Highest concentrations in the 2 AG sites and Cooper River site

Cooper River has a history of many sewage treatment plants

## **Bacteria:**

Fecal coliforms highest in Alloway Creek

Cattle observed jet-skiing in the creek

Coliforms high under high and low flow, growing and  
nongrowing seasons

Also high in Cooper River; attributed to geese and pets

## **Suspended solids:**

Not clearly related to land use

Higher during stormflow, particulates carried by runoff

Higher during the growing season

# Thank you for your attention

Questions:

Ron Baker, USGS

rbaker @ usgs.gov

609 771 3923

PDF of publication is available  
online:

[pubs.usgs.gov/sir/2010/5151/](https://pubs.usgs.gov/sir/2010/5151/)

